

S
627.83 Eastfork
U11erdh Reservoir Dam,
1930 Hill County,
Montana, MT. 1335

INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

48

EASTFORK RESERVOIR DAM
HILL COUNTY, MONTANA
MT. 1335

STATE DOCUMENTS COLLECTION

MAY 30 1991

PREPARED FOR:

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

BUREAU OF INDIAN AFFAIRS
ROCKY BOY'S RESERVATION
(OWNER - OPERATOR)

PREPARED BY:

PLEASE RETURN

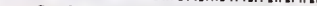


Christian, Spring, Sielbach & Associates
Bozeman, Montana

Assisted By:
Northern Testing Labs, Inc.
Great Falls, Montana
March, 1980



Seattle District
United States Army Corps of Engineers



3 0864 00071789 5

S Eastfork
627.33 Reservoir Dam,
U11erdh Hill County,
1980 Montana, MT. 1335

[illegible]

TABLE OF CONTENTS

<u>PARAGRAPH</u>	<u>Page</u>
Executive Summary	i
Pertinent Data	iv
 <u>CHAPTER 1 - BACKGROUND</u>	
1.1 Introduction	1
1.1.1 Authority and Scope	1
1.1.2 Purpose	2
1.1.3 Inspection	2
 1.2 Description of Project	 3
1.2.1 General	3
1.2.2 Regional Geology - East Fork	3
1.2.3 Seismicity	4
1.2.4 Site Geology	4
1.2.5 Design and Construction History	5
 <u>CHAPTER 2 - INSPECTION AND RECORDS EVALUATION</u>	
2.1 Hydraulics and Structures	7
2.1.1 Spillways	7
2.1.2 Outlet Works	8
2.1.3 Freeboard	8
 2.2 Hydrology	 8
2.2.1 Physiography and Climatology	8
2.2.2 Reservoir Storage and Spillway Discharge	9
2.2.3 Estimated Probable Maximum Flood (PMF)	9
2.2.4 Flood Routing	9
 2.3 Geotechnical Evaluation	 10
2.3.1 Embankment, Foundation Conditions, Seepage and Drainage	10
2.3.2 Stability	11

TABLE OF CONTENTS
(Continued)

<u>PARAGRAPH</u>	<u>Page</u>
2.4 Project Operations and Maintenance	11

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1 Findings	12
3.1.1 Size, Hazard Classification, and Dam Safety Evaluation	12
3.1.2 Spillways	12
3.1.3 Outlet Works (Low Level Drawdown)	12
3.1.4 Spillway and Reservoir Capacity	12
3.1.5 Embankment Dam	13
3.1.6 Geotechnics - Site Geology	13
3.1.7 Stability	25
3.2 Recommendations	13

<u>REFERENCES</u>	15
-------------------	----

PHOTOS

- Photo 1 - Upstream Face and Left Abutment
- Photo 2 - Hydrothermally Altered Vein in Emergency Spillway
- Photo 3 - Downstream Left Abutment
- Photo 4 - Downstream Center of Embankment
- Photo 5 - Right Abutment to Center-Emergency Spillway
- Photo 6 - Outlet Pipe
- Photo 7 - Inlet to Principal Spillway Riser
- Photo 8 - Principal Spillway/Low Level Outlet Pipe
- Photo 9 - Emergency Spillway
- Photo 10 - Emergency Spillway

TABLE OF CONTENTS

(Continued)

PLATES

Plate 1 - East Fork Dam Vicinity Map

Plate 2 - Beaver Creek Drainage Map

Plate 3 - East Fork Dam Site Geology

Plate 4 - East Fork Dam Section

Plate 5 - East Fork Dam Spillway Rating

APPENDIX A

EXECUTIVE SUMMARY

Personnel of Christian, Spring, Sielbach & Associates, principal contractor and Northern Testing Laboratories, Inc., subcontractor, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC) and with representation from the United States Department of the Interior, Bureau of Indian Affairs, and the MDNRC inspected East Fork Reservoir Dam on 21 June, 1979, under authority of Public Law 92-367. The project is located in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ Section 23, Township 28 North, Range 16 East, on the East Fork of Beaver Creek within the boundaries of Rocky Boy's Reservation, Hill County, Montana. Bearpaw Lake is located approximately 10 miles downstream from East Fork Dam on the Beaver Creek drainage.

This report was compiled from information obtained during the on-site inspection, review of an in-house report prepared by the BIA, correspondence with Mr. Henry Kipp and Mr. John Vogle of the BIA, and analysis of available hydrologic information. The Probable Maximum Flood was developed using methods and procedures outlined by the Corps of Engineers. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

East Fork Dam was constructed in 1964 under the sponsorship of the Chippewa-Cree Tribe, with engineering and construction supervision services provided by personnel of the Bureau of Indian Affairs. The dam is owned by the Tribe, with operation and maintenance assistance provided by the BIA. The project was planned as a recreation and flood control facility.

The 41-foot-high earth dam impounds approximately 111 acre-feet of water at top of dam, assumed elevation 4640.0 feet MSL. All elevations used in this report are relative to this elevation. Mean sea level datum was estimated from USGS quadrangle map for this site, entitled Warrick, Montana. On the basis of criteria in the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The project is classified as having a significant (Category 2) downstream hazard potential.

The dam is located such that failure would damage the road and bridges downstream. There are no permanently inhabited dwellings immediately below the dam. The south boundary of Beaver Creek Park, owned and operated by Hill County, is approximately three miles downstream and Bearpaw Lake dam is located approximately ten miles downstream from East Fork Reservoir Dam. Sudden failure may endanger lives of people traveling on Beaver Creek Road immediately below the dam. It would raise lake levels in Bearpaw Lake and increase flows downstream from Bearpaw Lake. However, under normal conditions Bearpaw Lake has sufficient surcharge storage to contain the 111 acre-feet that would be released by a sudden



Digitized by the Internet Archive
in 2015

<https://archive.org/details/eastforkreservoi1980chri>

failure of East Fork Reservoir Dam. The conclusions on probable damage are based on the field visit and engineering judgment. No dam breach analysis or routing of a dam breach hydrograph was made for the downstream area.

Inspection criteria (Ref. 1) recommend that an intermediate sized project with a significant downstream hazard potential be capable of safely handling $\frac{1}{2}$ to the full probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Because of the limited downstream hazard potential, we recommend one-half of the PMF be adopted as the spillway design flood (SDF).

The estimated PMF for the 3.2 square mile drainage basin resulted from a general storm PMP developed for this dam safety study. The PMF has an estimated volume of 3420 acre-feet and a peak flow of 18,400 c.f.s. The emergency spillway has a discharge capacity of approximately 940 c.f.s. with the reservoir at assumed top of dam, elevation 4640.0 feet MSL. The routing of the PMF was started with the reservoir at emergency spillway crest, elevation 4634.0 feet MSL. Routing of the full PMF for East Fork Reservoir Dam indicates that the dam is overtopped when only 21 percent of the total PMF flood volume enters the reservoir. Routings of lesser hypothetical floods made by applying percentages to the PMF ordinates, showed that a flood corresponding to 8 percent PMF ordinates is just controlled by the project. The dam is constructed of materials that would rapidly erode and failure is likely to occur when overtopped by flood waters.

The visual inspection of the embankment revealed an active wave erosion bench on the upstream slope at normal pool elevation. The developed phreatic line appears to be well up on the downstream slope, at about elevation 4623+. The rock toe appears "plugged" at the interface with the embankment and is providing no drainage relief. The emergency spillway has significant erosion at outlet; high flows could attack the downstream toe of the dam and cause slope failure. There are signs of surface creep in the downstream slope of embankment. It is our judgment that the embankment is marginally stable at best and does not conform to the recommended guidelines regarding embankment stability.

On the basis of the field inspection and study of the hydrologic data, East Fork Reservoir Dam does not now conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the recommended SDF (spillway design flood) or stability requirements. The dam is in need of immediate attention.

RECOMMENDATIONS

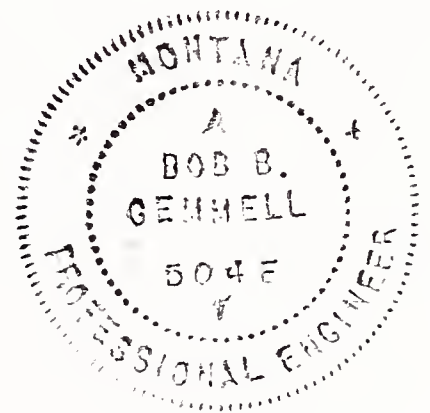
A downstream warning plan, for use in the event of possible dam failure, needs to be developed and immediately placed in action. Using the low level outlet, lower the reservoir to approximately sixteen feet below emergency spillway crest elevation as a minimum and maintain this elevation to the extent possible. Inspect the entire length of the combined principal spillway/low-level outlet and repair as required.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate.

Conduct stability and seepage studies including field exploration and laboratory testing of foundation and embankment materials to determine strengths and permeability characteristics. Determine the phreatic surface by the installation and monitoring of piezometers. Provide erosion protection above and below the normal pool elevation on upstream slope of dam.

Bob B. Gemmell

Bob B. Gemmell
Professional Engineer



PERTINENT DATA

1. General

Federal ID No.	MT-1335
Owner	Bureau of Indian Affairs Rocky Boy's Reservation
Operator	Unknown
Date Constructed	1964
Purpose	Recreation and Flood Protection
Location	NW $\frac{1}{4}$ NW $\frac{1}{4}$ Section 23, T28N, R16E, MPM
County, State	Hill County, Montana
Watershed	Upper Beaver Creek
Downstream Hazard Potential	Category 2 (Significant)
USGS Quadrangle	Warrick, Montana

2. Reservoir

Surface Area at Emergency Spillway Crest	8.88 acres
Drainage Area	3.2 square miles
Storage at Emergency Spillway Crest (elevation 4634.0 feet MSL)	54 acre-feet
Storage at Dam Crest (elevation 4640.0 feet MSL)	111 acre-feet
Surcharge Storage	57 acre-feet

3. Emergency Spillway

Type	Uncontrolled, unlined chute-cut in rock
Bottom Width	Varies, 15 to 20 feet
Crest Elevation	4634.0 feet MSL
Capacity with Reservoir at Dam Crest	940 c.f.s.

PERTINENT DATA

(Continued)

4. Outlet Works/Principal Spillway

Conduit Type	Corrugated Metal Pipe (CMP)
Principal Spillway Riser	24-inch-diameter CMP
Riser Height	35 feet
Principal Spillway Outlet	18-inch-diameter CMP
Outlet Length (riser to downstream toe)	122 feet
Low Level Outlet	18-inch-diameter CMP
Outlet Length (Reservoir Entrance to Riser)	88 feet
Gate at Entrance to Low Level Outlet	18-inch-diameter, slide gate

5. Dam

Type	Earth filled
Length	180 feet
Crest Width	Varies 15-19 feet
Crest Elevation (assumed)	4640 feet MSL
Hydraulic Height (crest to toe)	41 feet
Upstream Slope	1V on 3H
Downstream Slope	1V on 2H

CHAPTER 1 BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the East Fork Dam, owned by Bureau of Indian Affairs, Rocky Boy's Reservation, Hill County, Montana. The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of nonfederal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigation and evaluation of existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

- (1) a limited investigation to assess the general safety condition of the dam.
- (2) based upon an evaluation of the available data and a visual inspection.
- (3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
- (4) not intended to include extensive explorations, analysis, or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current physical and operational conditions of the dam and appurtenances; and to determine if emergency measures and/or additional studies, investigations, and analyses are needed, so that corrections can be made in a timely manner by the Owner.

1.1.3 Inspection

The findings and recommendations in this report are based on a review of construction plans and a post construction report pertinent to the original design and construction of East Fork Dam, and a visual inspection of the project. Inspection procedures and criteria were those established by the Recommended Guidelines for the Safety Inspection of Dams (Ref. 1).

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates (CSSA), and Northern Testing Laboratories, Inc., (NTL) subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA - Bob B. Gemmell, Engineer, Team Leader
Kent D. Brewer, Structural Engineer
Alfred Cunningham, Hydraulics/Hydrology (report only)

NTL - Robert Gillespie, Geotechnical Engineer
William Henning, Geologist

Other personnel present and participating in the field inspection included:

Glenn McDonald, Montana Department of Natural Resources and Conservation

Larry Tegg, Montana Department of Natural Resources and Conservation

Henry Kipp, Bureau of Indian Affairs, Rocky Boys Agency

This report has been reviewed by: The Bureau of Indian Affairs, and the State of Montana, and their written comments are enclosed in Appendix A "Correspondence".

1.2 DESCRIPTION OF PROJECT

1.2.1 General

a. Location, Owner, and Purpose

East Fork Reservoir Dam is located on the East Fork of Beaver Creek within the Rocky Boys Reservation in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ Section 23, Township 28 North, Range 16 East, M.P.M., in Hill County, Montana (Plate 1). The dam was constructed in 1964 by resolution and sponsorship of the Chippewa-Cree Tribe as a flood prevention and recreation project. Feasibility studies and engineering was provided by BIA personnel.

The dam is owned and operated by the Chippewa-Cree Tribe with assistance in operation provided by the Bureau of Indian Affairs.

b. Description of Dam and Appurtenances

East Fork Reservoir Dam is an earth filled structure with a height of 41 feet from downstream toe to crest of dam assumed elevation 4640 feet MSL. All elevations used in this report are based on assumed elevation 4642 feet MSL for the top of concrete gate hoist lift base; elevation 100.0 assumed for survey made at time of inspection. Mean Sea Level datum was estimated from the USGS quadrangle labeled Warrick, Montana. The dam impounds approximately 111 acre-feet at dam crest elevation 4640 feet MSL, the low point in the crest profile. It impounds approximately 54 acre-feet at emergency spillway crest elevation 4634 feet MSL. The emergency spillway is cut in rock on the east or right abutment (Photos 9 & 10).

The low level outlet and the principal spillway are combined into a single structure located near the center of the dam (Plate 4). The low level outlet conduit is 18-inch-diameter corrugated metal controlled by a slide gate at inlet. The uncontrolled principal spillway riser is 24-inch-diameter corrugated metal and the outlet pipe is 18-inch-diameter corrugated metal.

c. Hazard Potential

The National Dam Safety Inventory designates the project as MT-1335 and lists it as having a low (Category 3) downstream hazard potential in case of failure. Based on visual reconnaissance and engineering judgment, East Fork Reservoir Dam is located such that a sudden breach could cause damage to the highway and bridges downstream. It may endanger lives of people traveling the Beaver Creek road immediately below the dam. It would raise reservoir levels in Bearpaw Lake which is approximately ten miles downstream. The potential hazard to Bearpaw Lake Dam that would be attributed to overtopping and failure of East Fork Dam during the routing of the PMF or a lesser flood event is undetermined.

On the basis of this information and in accordance with the recommended guidelines, the project size is intermediate and the downstream hazard potential is raised to significant (Category 2).

1.2.2 Regional Geology - East Fork

The Bearpaw Mountains region contains a wide range of intrusive and extrusive rocks of the Eocene age.

The extrusive rocks are a wide assortment of flows and flow breccia, pyroclastic deposits and volcanic sediments. The intrusive rocks occur as dikes, sills, plugs, and stocks. The volcanic rocks consist of an irregular assortment and wide variety of mafic and felsic rocks and their intrusive equivalents. The mafic extrusive rocks exceed the felsic in volume.

"Regional sedimentation in the Bearpaw Mountains region continued from Paleozoic into early Eocene time and ceased with the deposition of channel boulders derived from the Rocky Mountains region to the southwest. Deformation interrupted sedimentation and was followed by erosion and by the eruption of a great variety of intrusive and volcanic igneous rocks in the remaining part of the Eocene epoch. Deformation continued concurrently with igneous activity, but probably ceased in late Eocene time with collapse faulting of the mountainous area. Erosion during the remaining part of the Tertiary developed the present mountainous configuration and established a drainage pattern that was adjusted to the late Tertiary Missouri River system. A continental ice sheet advanced southeasterly across the northern half of the quadrangle in late Pleistocene time, abutted against the high terrain of Number One Mountain and Mount Reynolds, filled the lower stretches of the existing valleys with till, and covered with drift all the pediment surfaces and interstream area below about 4200 feet in altitude. The present stream courses are largely the result of consequent drainage on ground moraine, and locally, as along Beaver Creek, part of preglacial valleys have been resurrected. Evidence for more than one ice sheet is not available. Post-glacial dissection in some places exceeds 150 feet."¹

The volcanic rock exposed in the Bearpaw Mountains can be distributed into a northern and southern field, with the volcanic rocks in the area of East Fork Dam constituting the central part of the northern field. After volcanism ceased, the rocks were faulted and tilted. Total thickness of these volcanic rocks is greater than 10,000 feet.

1.2.3 Seismicity

The Bearpaw Mountain region is in an area of generally minor seismic activity (borderline Zone 1 and 2). Maximum seismic events in this area are expected to be less than Richter Magnitude 5.0. According to the Recommended Guidelines for Safety Inspections (Ref. 1), associated ground surface accelerations on the order of 0.025 to 0.05g are anticipated.

Based on generally available information, there are no historic events in the Havre area.

1.2.4 Site Geology

A limited subsurface investigation of this area, was made by the Bureau of Indian Affairs, with several test pits being made. Locations are

¹ Preliminary Geologic Map of the Shambo Quadrangle, Bearpaw Mountains, Montana. Map 1-236 USGS.

described on the logs (Ref. 8). These test pits, along with a visual examination of the area, were used to prepare the following site description.

The dam has been constructed in a narrowed part of the valley formed by downcutting of the creek channel through a mafic volcanic ridge striking perpendicular to Beaver Creek (Photo 1). Alluvial soils in the creek are largely granular, ranging from gravel to occasionally silt size. They are derived from the weathering of the surrounding volcanic rocks. Bedrock is approximately 5 feet deep in the vicinity of the creek channel, and from 3.5 to 5.5 feet in the abutment areas. Consequently, it is believed the dam is founded near the top of rock and is at least partially tied to bedrock.

A small spillway has been cut into bedrock on the right abutment (Photos 9 & 10). A hydrothermally altered volcanic vein in the bedrock outcrops just below the spillway and has been eroded by water. The vein is loose and crumbly, weathering easily (Photo 2). The vein can be seen across the gravel road to the north and appears to be striking roughly N7°E, cutting across the dam and faintly outcropping on the upstream side of the left abutment (Plate 3).

Bedrock is exposed at numerous locations in the reservoir area and major overburden slides into the reservoir are not considered a problem. Detailed abutment descriptions follow.

Right Abutment. This abutment is founded in mafic volcanic rocks. The rocks are highly fractured and jointed, with no particular orientation of joints or fractures seen. The mafic rocks are black to dark gray, aphanitic, with some very small and scattered phenocrysts of plagioclase, augite and olivine. An alteration or oxidized zone, striking N11°E, is encountered about 50 feet northwest of this abutment. This altered zone is bounded on both sides by very hard black mafic rocks. The altered zone is reddish-brown in color, very crumbly and fractured. These rocks have a considerable amount of biotite and augite in them. This altered zone can be seen to the north of the gravel road, may continue diagonally across the dam, and may be an extension of the same zone at the left abutment. The creek on this side has cut down through this altered zone about 6 feet, until it encountered the hard mafic rocks, and this downcutting has been slowed.

Left Abutment. This abutment is also found in mafic volcanic rock. The rock is similar to the right abutment. These outcrops are ribbed, which is most likely an erosional feature.

Other geologic-related topics are discussed in the geotechnical evaluation.

1.2.5 Design and Construction History

The following was abstracted from a post construction report entitled "East Fork of Beaver Creek Reservoir", B.I.A. (Ref. 8).

The project was first conceived by the Chippewa-Cree Tribe in 1960. Preliminary investigations were made and a cost estimate was given the Tribe. The Tribe was unable at this time to stand the cost.

In 1963 further investigations were conducted by BIA personnel at the request of the Tribe, construction plans were prepared and construction was authorized.

The construction of the project was scheduled to start April 15, 1964. On April 15 there was approximately three feet of snow at the dam site and no access road constructed. Construction layout was done the first part of May under adverse conditions, and construction was started under force account in mid-May 1964. Initial construction was hampered by rain and equipment breakdowns. Foundation preparations, core trench excavation, and backfill were completed under conditions that would have produced questionable results. Construction was completed on August 22, 1964.

CHAPTER 2 INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillways

a. Principal (pipe) Spillway

The principal spillway is a 24-inch diameter corrugated metal pipe vertical riser approximately 35 feet high. An 18-inch diameter corrugated metal pipe outlet approximately 122 feet long connects to the bottom of the riser and extends through the embankment (Plate 4). The crest of the 24-inch diameter riser is at approximate elevation 4633.8 feet MSL. Hydraulic characteristics of the inlet to riser are very poor. The sloping trash guard will plug with trash very easily and the timber headwall restricts weir capacity of the drop inlet. Weir flow at the inlet controls capacity of the drop inlet until approximately 1.7 feet of head on weir has developed at which point full pipe flow in the 18-inch diameter outlet pipe controls. With reservoir at crest of dam elevation 4640 feet MSL the estimated capacity of the principal (pipe) spillway is about 30 c.f.s. Energy losses in the 18-inch-diameter cmp were accounted for by using a mannings "n" of 0.025 for full pipe flow.

At the time of field inspection the reservoir elevation was at about 4634.0 feet MSL. A small flow was passing through the emergency spillway, and although the top of the principal spillway riser was inundated there was a very small flow at outlet, indicating that the riser was partially plugged. There was very little evidence of water movement at the entrance to the riser. Because the riser was inundated, it was not possible to inspect the combined principal spillway/low level outlet.

b. Emergency Spillway

An emergency spillway was cut in rock at the east (right) abutment of the dam. This spillway has about 15 foot width at crest elevation 4634.0 feet MSL and about a 45 foot top width at top of dam elevation 4640.0 feet MSL. Side slopes of the spillway are variable (See Photos 9 & 10). Because the emergency spillway crest is at the same elevation as the principal spillway crest, long duration low flows are experienced in the uncontrolled emergency spillway.

Visual inspection revealed that the emergency spillway is used frequently. The crest is uneven and erosion has occurred in the soft rock downstream from the crest. Long duration low flows have accelerated erosion. Some debris was lodged in the spillway at an elevation below crest. Although the debris may not impede flow it would cause turbulence that could accelerate erosion in the soft rock. In its present condition, and with frequent use, the erosion of the soft rock will continue. The uncontrolled erosion of the exit channel would cause flows to impinge on and to undermine the downstream toe of the dam, possibly resulting in slope failure. The estimated capacity of the emergency spillway is approximately 940 c.f.s. with reservoir elevation at top of dam. Spillway discharge rating data is presented on Plate 5 and assumes critical depth occurs at the entrance to the channel spillway.

2.1.2 Outlet Works

The low level outlet is in an 18-inch diameter corrugated metal pipe approximately 88 feet long from inlet to connection at the bottom of the 24-inch diameter principal spillway riser pipe. From riser to outlet the 18-inch diameter pipe is approximately 122 feet in length. The inlet is controlled by an 18-inch diameter slide gate with hoist located at the top of dam. The gate stem is encased in a galvanized pipe and is buried in the upstream face of the dam (Plate 4).

The handwheel lift for the low level outlet was chained and padlocked to the hoist base at time of visit; and the key for unlocking was unavailable. Mr. Henry Kipp of the Bureau of Indian Affairs advised that to his knowledge, the low level outlet had not been operated in the past ten years. The 18-inch diameter CMP has been bent down at the outlet end, causing a slight constriction that would reduce capacity at full pipe flow. The pipe is unsupported at the outlet near the toe of the dam and high flows could undermine the structure. It could not be determined if the pipe had protective coating and whether "watertight" bands had been used for joining lengths of pipe.

The estimated capacity of the low-level outlet is approximately 20 c.f.s. with water surface in the reservoir at 4634 feet MSL.

2.1.3 Freeboard

Routings indicate the dam will overtop during the PMF; therefore freeboard does not exist with the recommended spillway design flood. A very small flow was passing through the emergency spillway at the time of inspection (Photo 9). It is suspected that emergency spillway flows occur during each spring runoff period.

The freeboard relative to crest of emergency spillway elevation 4634 feet MSL is about 6 feet to the low point in dam crest. Maximum lake levels attained could not be determined by visual inspection. At normal pool elevation, wind generated waves would not be expected to overtop the embankment.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The East Fork Reservoir is located in the upper Beaver Creek drainage in northcentral Montana in the southeastern part of Hill County. The East Fork drainage is about 2.1 miles long and about 1.5 miles wide, covering approximately 3.2 square miles. The main tributary to the reservoir, is a small ephemeral stream fed primarily by snowmelt runoff from the Bearpaw Mountains. Elevation of East Fork Reservoir is about 4640 feet MSL. Latitude at center of basin is 48°17" and longitude is 109°40'.

Average annual June through October precipitation at the nearby Rocky Boy's permit No.2 precipitation station (El. 5200 ft.) is 12.34 inches, 60% of which occurs during May and June. An additional 4.5 inches of average April 1 snowpack water equivalent is observed bringing the total average annual precipitation at Rocky Boy to about 16.9 inches. Temperature variations are extreme in this region ranging from 100°F in summer

to -40°F in winter months. The average annual frost-free period is 139 days with the last day of frost varying from late May to early June. Average annual lake evaporation is approximately 38 inches of which 80% occurs during May-October.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 8.88 acres and a storage of 54 acre-feet at emergency spillway crest, elevation 4634 feet MSL, which is very near the crest elevation of the principal spillway. Approximately 57 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest elevation 4640 feet MSL. The emergency spillway discharge with the reservoir at the dam crest is 940 c.f.s. (Plate 5).

2.2.3 Estimated Probable Maximum Flood (PMF)

The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

The PMF for East Fork Reservoir was developed using the HEC-1 Flood Hydrograph-Dam Safety Investigation Computer Program (See Ref. 2). Primary program input consisted of the 72-hour probable maximum precipitation (PMP) which was obtained for the study site from Ref. 3). Generalized estimates of the PMP for 10 square miles for durations of 1, 6, and 24 hours were obtained from charts in Ref. 3. PMP values for 48 and 72 hour durations were estimated as 110% and 115% respectively of 24 hour PMP. A depth-duration curve was plotted from which one hour incremental rainfall values were determined and subsequently arranged in a critical sequence according to Ref. 4. Total precipitation for a 72-hour period is 20.13 inches with a maximum hourly value of 7.50 inches.

The PMF hydrograph was developed based on a synthetic unit hydrograph (UHG) constructed using procedures outlined in Ref. 5. In calibrating the SCS unit hydrograph for input to HEC-1 a basin time of concentration of .58 hours was used along with an incremental storm duration of 10 minutes. Combination of the critical PMP sequence with the UHG resulted in the PMF inflow hydrograph to East Fork Reservoir. It was assumed that frozen soil conditions prevailed during the PMP resulting in an infiltration rate of zero.

The resulting PMF peak inflow to East Fork reservoir was found to be 18,400 c.f.s. while total inflow volume was 3420 A.F.

2.2.4 Flood Routing

Routing of the PMF hydrograph through the project was accomplished by means of the computer program, HEC-1. (Ref. 2) Initial water surface elevation in the reservoir was assumed to be at emergency spillway crest elevation 4634.0 feet MSL at onset of PMF. Zero initial inflow or outflow was assumed. Routing was accomplished using the modified puls method. Routings were made of hypothetical floods less than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates.

Routing studies indicate that:

- a. During the full PMF the dam would be overtopped when approximately 21 percent of the total flood volume enters the reservoir.
- b. A flood with a hydrograph corresponding to 8 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

East Fork Dam was built by the Bureau of Indian Affairs following an extremely limited subsurface investigation. The thrust of this investigation appeared to be primarily toward identifying borrow sources rather than establishing subsurface conditions at the embankment site. The post construction report was made available to us and was used in this evaluation (Ref. 8).

2.3.1 Embankment, Foundation Condition, Seepage, and Drainage

The embankment is approximately 41 feet high with a crest width of about 15-19 feet. The original design elevation is not known. The downstream slope is irregular (Photos 3, 4, 5, and 6), but averages about 2 horizontal to 1 vertical (Plate 4). The upstream slope was planned at 3 horizontal to 1 vertical, but at the time of our inspection, the exposed portion was about 2.5 horizontal to 1 vertical. The slope is interrupted by a significant wave action erosion bench (Photo 1). There is no riprap or other form of slope protection on the upstream slope.

The embankment was apparently constructed using local materials. Although there is no specific statement regarding borrow source areas, test pit locations indicate borrow came from within the reservoir area. The major portion of the embankment appears to be a silty clay with a downstream (drainage) toe of volcanic rock. No instrumentation was installed.

As stated in the geology section, the dam is built in a narrow valley formed by downcutting of the rock by the creek. From the construction report and pictures included in the report, the dam appears to be founded on rock at the abutments and in the core trench area. The dam was constructed under extremely adverse conditions, as evidenced by the photographs in the construction report. The core trench and lower portion of the embankment appear to have been placed in standing water (Figures 71, 79, and 81 BIA report, Ref. 8). This would result in drastically reduced shear strengths, increased compressibility, and lack of density.

Our inspection revealed that there is considerable seepage exiting the downstream toe and face (Photos 7 and 8). The phreatic surface appears to be considerably higher than would be expected if the drain was functioning properly. The observed exit point of the phreatic surface is about elevation 4623(+) on the downstream slope, well above the toe. Seepage quantity is difficult to assess because of the broad extent of the seeped area. We did observe that free water is entering the rock drain from the slope above it, and in some cases, the seepage formed small rivulets. We also noted a bog-like area on the left side of the downstream channel. It is not known if this is a natural spring or dam related.

The toe "drain" is composed of varying sizes of volcanic rock fragments. However, it appears too coarse to serve as a proper filter for the clay embankment material and may have been plugged by the clay as it was placed. This is a possible explanation of the high phreatic line. In view of the construction methods, seepage may also be the result of improperly scarified compaction planes, or layers of coarser, relatively pervious material may have been placed across the width of the embankment.

All observed seepage was clear and there was no evidence of boils or piping erosion.

Our review of the data indicates that the foundation may have received inadequate treatment. The probability of uncontrolled seepage is unacceptably high. Reduced flow from the outlet pipe was observed indicating a possible block, constriction, or joint separation. In view of construction conditions and the apparent softness of core trench and lower embankment soils, the pipe could be bent by settlement of core trench materials under the embankment or pulled apart by lateral spreading of the foundation soils. This requires investigation.

The downstream slope shows considerable evidence of near surface and perhaps more deeply seated creep. There are numerous small hummocks and there is a slight concavity to the slope which gives the appearance of scarp formation. We did not observe any distinct scarps at the time of our inspection. Several areas of small cracks were observed on this slope. The cracks were short (1-3 feet), narrow (less than or equal to 3/8 inch) and roughly parallel to the crest. They had the appearance of desiccation cracks influenced somewhat by external stresses such as tension in the soil. The majority of these occurred above the observed phreatic line.

Only a small portion of the upstream slope was above water (elevation 4634+), and inspection did not reveal any problems other than wave erosion.

Vegetation is predominantly rye grass. Growth is somewhat sparse on the upstream face, while it is thick and lush on the downstream side.

2.3.2 Stability

We were unable to find any record of stability analyses of the embankment. Based on observed behavior, we conclude the embankment is marginally stable at best.

2.4 PROJECT OPERATIONS AND MAINTENANCE

There is no formal plan for operations and maintenance. A BIA resource staff member visits the East Fork Dam every spring during and after the mountain stream runoff cycle. There are no records of repairs being made during the life of the dam. Maintenance has been limited to removal of obstructions from the spillway from time to time.

A formal early warning plan or procedure to rapidly alert downstream interests in the event of impending failure has not been developed.

CHAPTER 3 FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by a report on planning and construction prepared by the Bureau of Indian Affairs (Ref. 8), and a study of construction plans in terms of the Guidelines (Ref. 1) performance standards resulted in the following findings.

3.1.1 Size, Hazard Classification, and Dam Safety Evaluation

The 41-foot-high East Fork Reservoir Dam impounds about 111 acre-feet of water with reservoir at the crest of the dam. In accordance with inspection guidelines, the dam is intermediate in size with a significant (Category 2) downstream hazard potential rating. The recommended spillway design flood (SDF) for this project is $\frac{1}{2}$ of the PMF. The project can safely control only 21 percent of the PMF flood volume and 8 percent of PMF ordinates. Because the project is incapable of controlling the recommended SDF without overtopping and causing the dam to fail and stability and seepage problems exist, East Fork Reservoir Dam does not conform to the recommended guidelines and urgent action is necessary to correct the deficiencies.

3.1.2 Spillways

a. Principal Spillway

Visual inspection of the entrance to the 24-inch diameter riser and trash rack shows that it is very susceptible to plugging with minor amounts of debris. The riser structure could not be inspected during the site visit due to reservoir level. Although the riser was submerged, the flow at outlet was much less than would be expected. This indicates it is partially plugged or possibly damaged by settlement of core trench material or foundation spreading. The condition of corrugated metal pipe with respect to corrosion and seepage at connections could not be determined. The outlet at the downstream toe of dam is unsupported, has no energy dissipator and undermining potential is high.

b. Emergency Spillway

The elevation of the crest of the emergency spillway appears to have been lowered sometime after construction was completed. There are signs of erosion in the "soft" rock and the spillway is apparently used frequently. Inlet conditions are such that clogging is very likely. A log was lodged in the exit channel at time of visit. The spillway exits very near the downstream toe of dam. High flow could attack and erode the toe of the dam, possibly resulting in slope failure.

3.1.3 Outlet Works

The handwheel lift mechanism was chained and padlocked at the time of visit. It apparently had not been operated for several years. The condition of the 18-inch diameter gate and pipe is unknown. The gate is not vented and cavitation is likely. There is no energy dissipator at the outlet. Erosion could undermine the pipe if prolonged high flows occurred.

3.1.4 Spillway and Reservoir Capacity

The reservoir has a surface area of about 8.88 acres and a storage of 54 acre-feet at assumed emergency spillway crest, elevation 4634 feet MSL.

Approximately 57 acre-feet of surcharge storage is available between emergency spillway crest and the dam crest at low point. Since the principal spillway crest elevation is very near emergency spillway crest elevation there is no additional surcharge storage available. The discharge of the emergency spillway, with the reservoir at the dam crest, is about 940 c.f.s.

3.1.5 Embankment Dam

The upstream slope is interrupted at water line elevation 4634.0 feet MSL (spillway crest) with a significant wave erosion bench. No riprap was evident to protect against erosion. The downstream slope shows considerable evidence of near surface and perhaps more deeply seated creep. No foundation or embankment drainage other than the rock toe was installed. The rock toe which originally may have been intended to lower the seep line in the embankment is apparently ineffective as seepage is evident at both abutments and in the embankment well up on the downstream slope. Foundation settlement appears to be minor since the embankment is apparently founded on shallow overburden over non-yielding rock. This is based on visual observations since the original constructed elevation is unknown. Foundation preparation and backfill was accomplished in wet conditions not conducive to optimum compaction. The probability of uncontrolled seepage and potential for piping at foundation contact is unacceptably high.

3.1.6 Geotechnics - Site Geology

The site has a good foundation, however site preparation and initial fill placement were reportedly conducted under very adverse conditions.

3.1.7 Stability

In light of observed material behavior and high piezometric surface, stability of the downstream embankment slope under present loading conditions appears very marginal. The potential for increased loading and high spillway flows that would threaten to undermine the downstream toe and could cause slope failure should not be ignored. It is our judgment that embankment stability does not conform to recommended guidelines (Ref. 1).

3.2 RECOMMENDATIONS

East Fork Reservoir Dam in its present condition provides no detention storage between crest of principal spillway and crest of "emergency" spillway that could be controlled by the principal spillway at a "regulated" release rate. The emergency spillway operates frequently for long periods of time. Therefore, no flood protection is afforded for flood events of 25 year frequency or less. The intent of report recommendations is to provide a basis for design of project modifications that will enhance flood protection capabilities and the overall stability of the dam.

- 1.--Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress.
- 2.--Using the low level outlet, immediately lower the reservoir to approximately the height of the top of the rock drain (elevation 4618+). This amounts to a drawdown of approximately 16 feet below emergency spillway crest. Maintain the lowered reservoir elevation to the greatest extent possible, given the small discharge capacity.
- 3.--Inspect the entire length of the principal spillway/low-flow outlet conduit through the dam embankment and repair as required.

- 4.--Conduct and place on file, stability and seepage analyses of East Fork Dam. We recommend these analyses be performed by a geotechnical engineer experienced in dam design and be based on: seismic and static loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and embankment pore pressures. Determine the seismic response of the dam based on a seismic assessment of the area. Establish the material strength properties by drilling, sampling, and appropriate laboratory testing. Obtain the phreatic surface and embankments pore pressures by installing and monitoring piezometers. Design structure modifications suggested by this program and implement to enhance stability and safety of the dam
- 5.--Provide upstream slope protection and debris control at entrance to spillways.
- 6.--Provide protection at the downstream end of both the outlet works and the emergency spillway to prevent possible erosion at the toe of the embankment.
- 7.--Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate.
- 8.--Operations and maintenance personnel should monitor the condition of the dam frequently until recommended studies are completed.
- 9.--Initiate a program of regular periodic inspections by qualified engineers at not-to-exceed five-year intervals.

REFERENCES

1. U.S. Army Corps of Engineers, Office the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C.; Department of the Army, May 1975.
2. U.S. Corps of Engineers, HEC-1 Flood Hydrograph Package Dam Safety Investigations, Davis CA, Sept. 1978.
3. U.S. Weather Bureau. Technical Paper No. 38 - Generalized Estimates of Probable Maximum Precipitation for United States West of 105 Meridian, 1960.
4. U.S. Weather Bureau, Hydrometeorological Report No. 43 - Probable Maximum Precipitation Northwest United States.
5. Soil Conservation Service, SCS National Engineering Handbook Section 4, Hydrology, 1972.
6. U.S. Bureau of Reclamation, Design of Small Dams, Second Ed. 1974.
7. U.S. Soil Conservation Service, Hydrology of Beaver Creek, Havre, MT. In house report, Bozeman Office, 1967.
8. Bureau of Indian Affairs, East Fork of Beaver Creek Reservoir, Rocky Boys Reservation, In House Report, 1964.

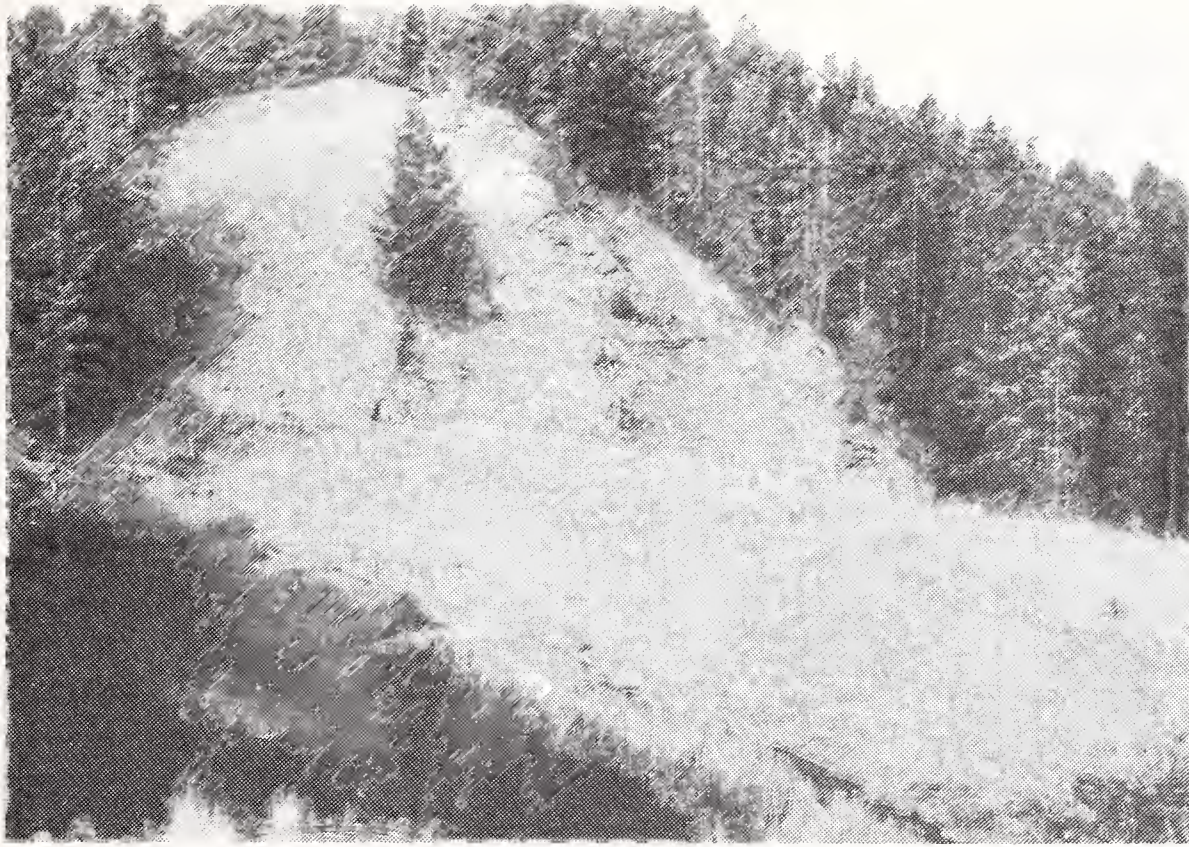


PHOTO 1 - Upstream face and left abutment
Note erosion bench at water line



**PHOTO 2 - Hydrothermally altered vein in
emergency spillway (highly erodable)**



PHOTO 3 - Downstream Left Abutment
Note erosion at trough



PHOTO 4 - Downstream center of embankment
Evidence of surficial sloughing



PHOTO 5 - Right abutment to center
Emergency spillway upper left



PHOTO 6 - Outlet Pipe
Note seepage above outlet pipe at toe



PHOTO 7 - Inlet to trickle tube riser
 Note erosion at water line - Poor hydraulic characteristics and plugging potential



PHOTO 8 - Outlet pipe for trickle tube
 Note low flow (Emergency spillway flowing at same time)

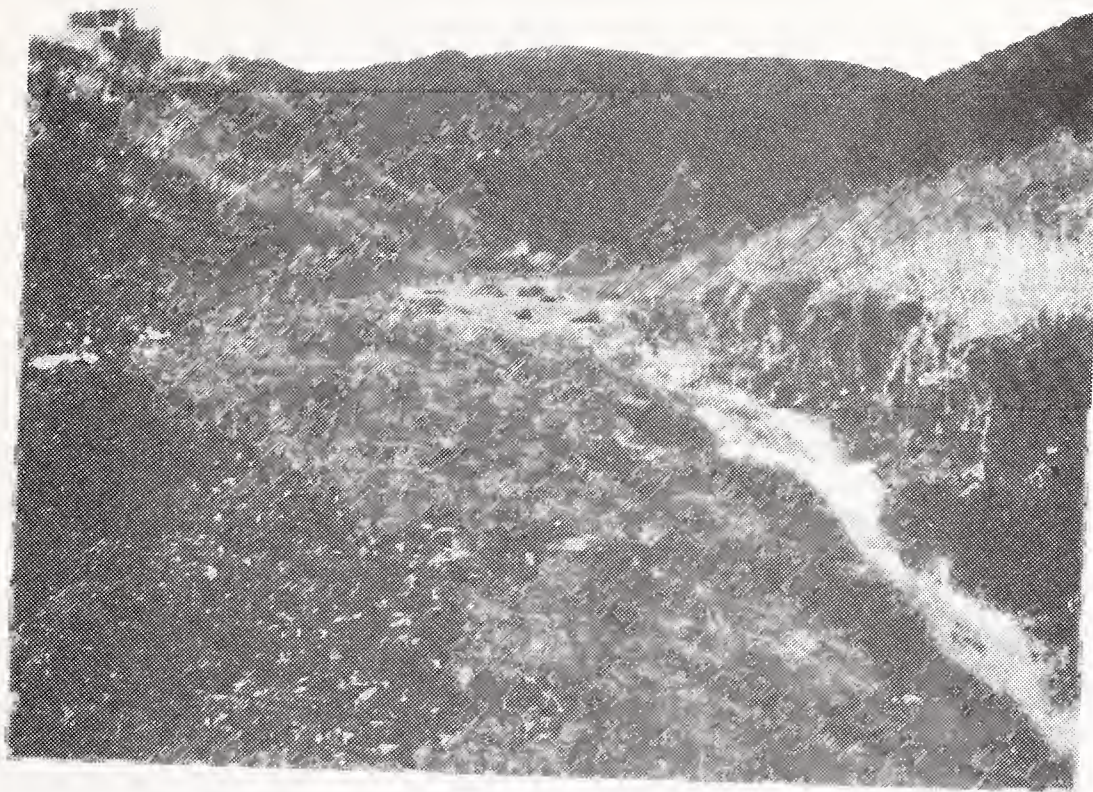


PHOTO 9 - Emergency spillway (looking upstream)
Note small flow on right and erosion



PHOTO 10 - Emergency spillway
(Looking upstream)

R16E

T29N

T28N

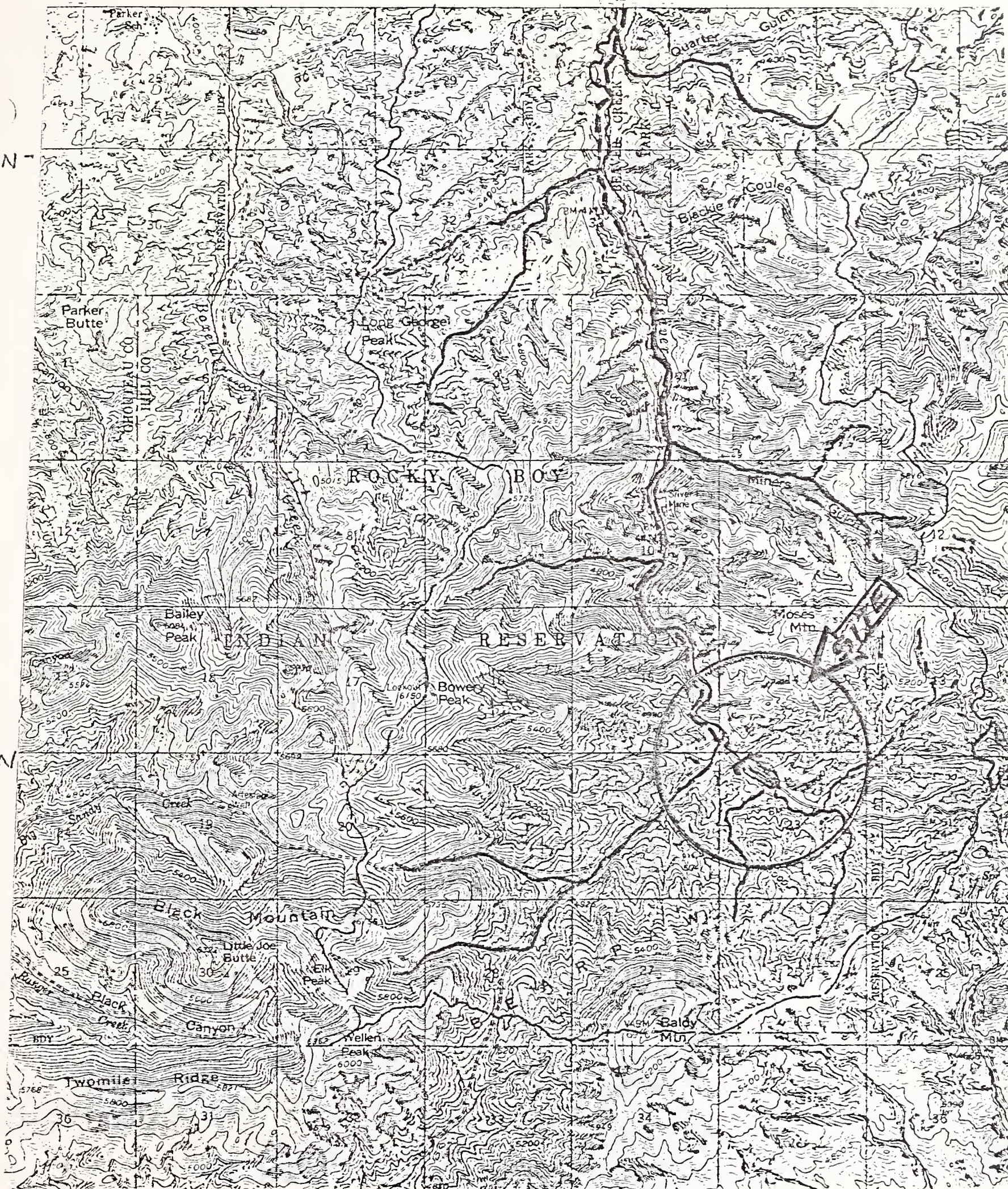


PLATE I
EAST FORK DAM
VICINITY MAP

MILK
RIVER

HAVRE

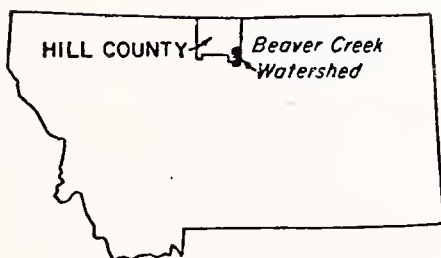
BEAVER CREEK WATERSHED

HILL COUNTY, MONT.



BEAVER CREEK
RESERVOIR

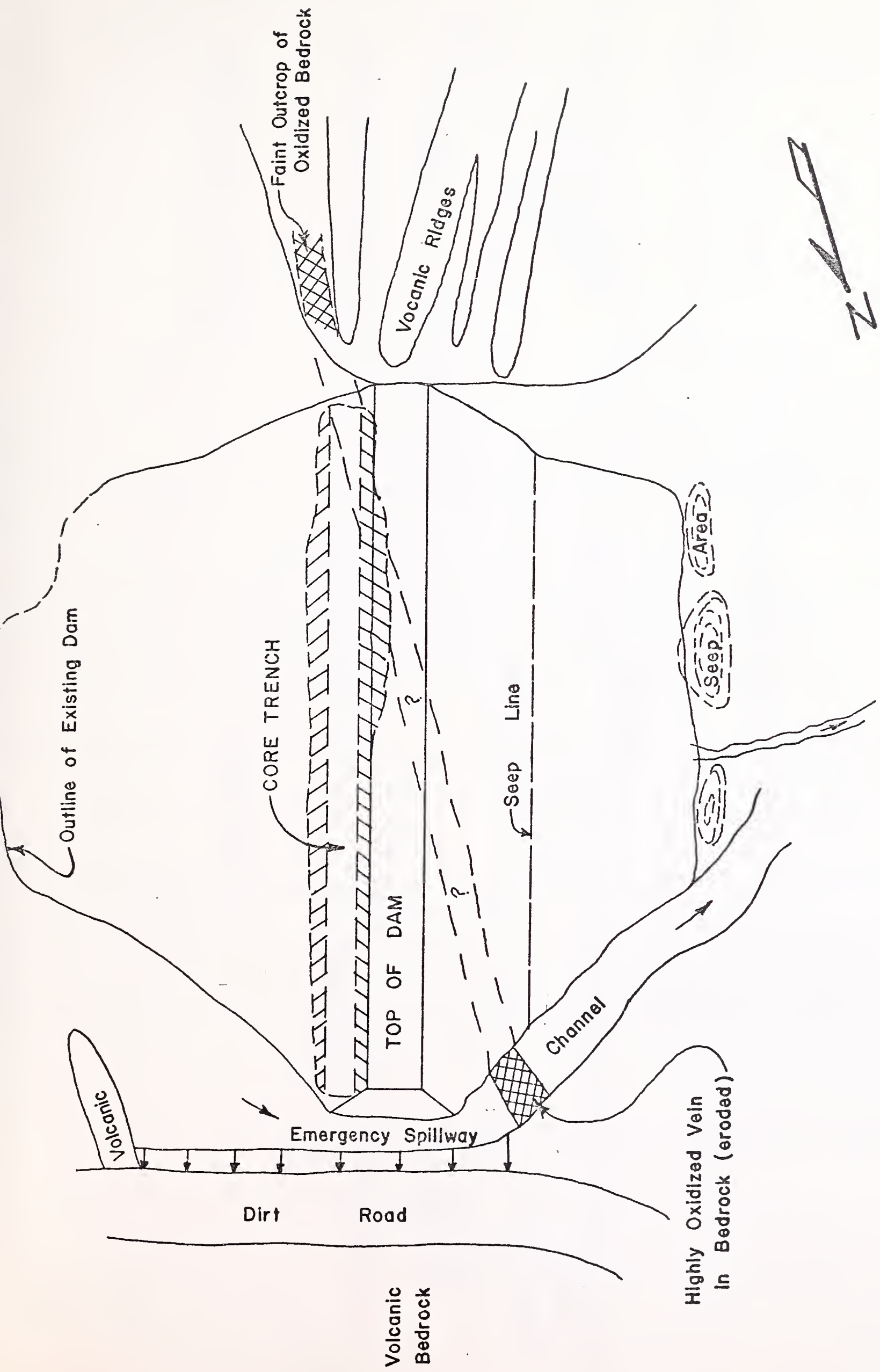
BEARPAW LAKE



LOCATION MAP

EAST FORK
DAM

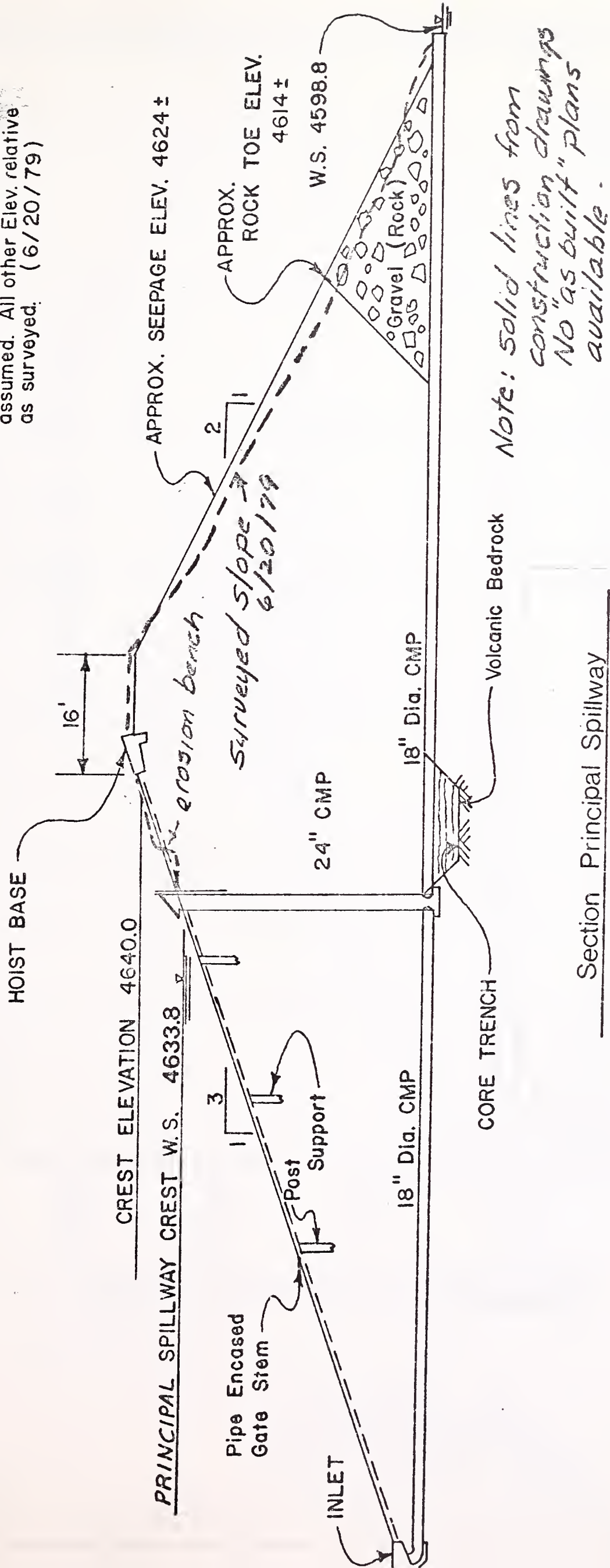
PLATE 2
BEAVER CREEK
DRAINAGE



SITE PLAN OF DAM

SCALE - 1" = 40'

NOTE: Top of Dam MSL Elev. assumed. All other Elev. relative as surveyed. (6/20/79)



Section Principal Spillway

SCALE - 1" = 20'

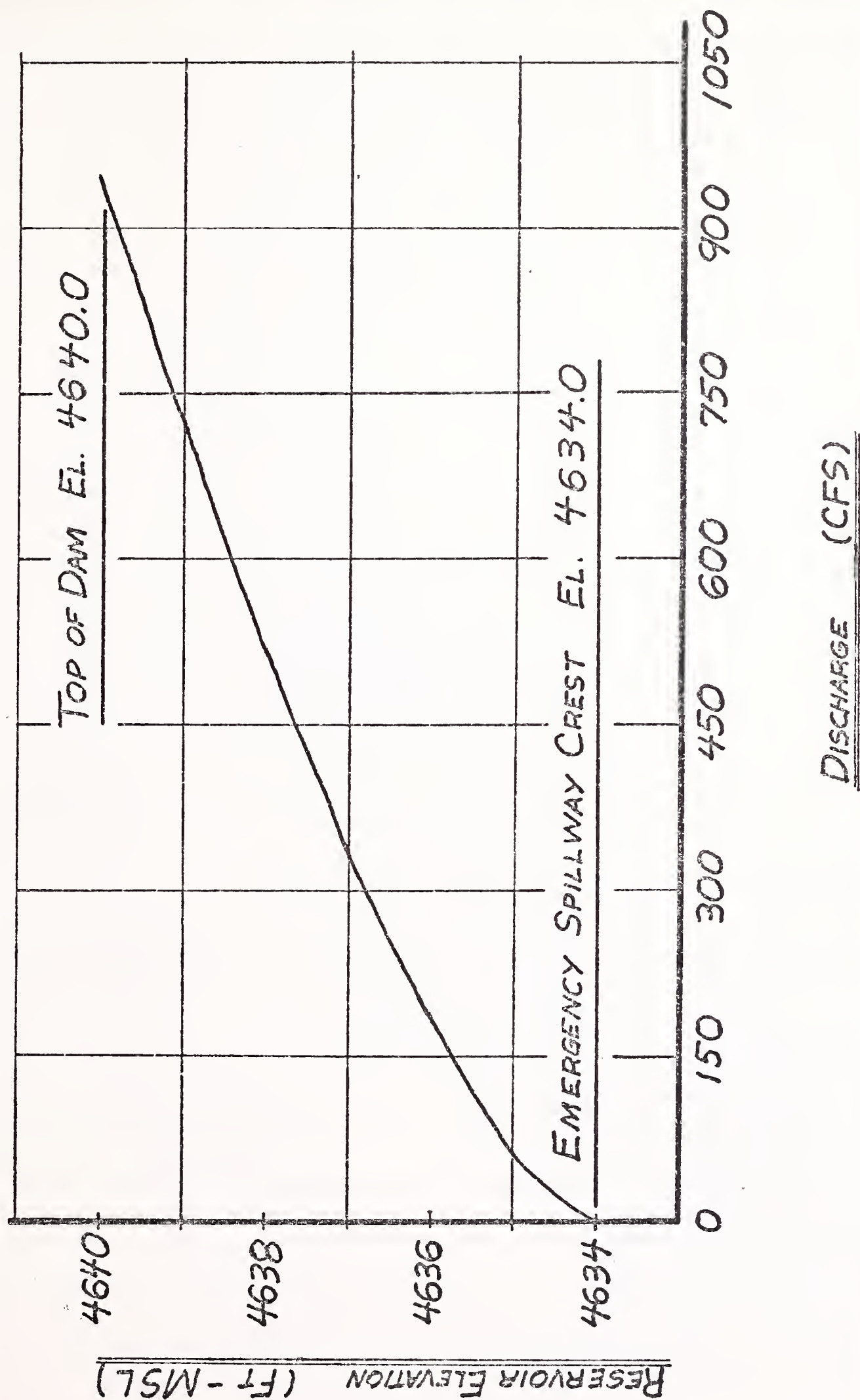


PLATE 5

EAST FORK DAM
EMERGENCY SPILLWAY RATING CURVE

A P P E N D I X A

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION



THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

HELENA, MONTANA 59601

(406) 449-2872

June 20, 1980

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Ralph:

The Department of Natural Resources and Conservation has reviewed the final draft report on the East Fork Reservoir Dam (MT-1335). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

A handwritten signature in cursive script that reads "Richard L. Bondy".

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/LT/mb



United States Department of the Interior

BUREAU OF INDIAN AFFAIRS

BILLINGS AREA OFFICE

316 NORTH 26TH ST.

BILLINGS, MONTANA 59101

IN REPLY REFER TO:
Rights Protection
IPF 21 Corps of
Engineers

JUL 02 1980

Department of the Army
Corps of Engineers
P.O. Box C3755
Seattle, Washington 98124

Gentlemen:

This is in reference to the final draft - Phase I - Inspection report National Dam Safety, East Fork Reservoir Dam, Rocky Boy's Reservation (March 1980).

We have received the above subject report and we are concerned with the overall stated condition of the structures.

We are questioning the estimated PMF results from a general storm PMP developed for this study. We would like the design storm arrangement (precipitation, depth, duration date, unit graphs, etc.).

The site geology did not address the porosity and permeability of the soils or bedrock of the study area.

We are cleaning the principal spillway. The corrugated metal pipe appears to be in fair condition and at this time, the alignment appears to be very good. The pipe had protective coating and water tight bands were used at the time of the construction.

Plans are being made to determine the origin of the seepage and emergency spillway repair.

We would appreciate copies of the following references which were used for this study. Reference requested are from page 27.

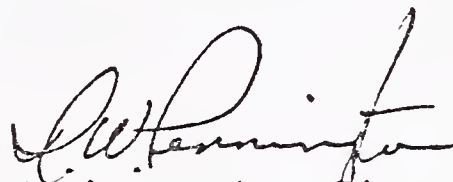
2. Hill County Soil and Water Conservation District et.al.,
Watershed Work Plan Beaver Creek, Hill County, Montana,
Sept. 1967.



3. U.S. Corps of Engineers, HEC-1 Flood Hydrograph Package Dam Safety Investigations, Davis CA, Sept. 1978.
4. U.S. Weather Bureau. Technical Paper No. 38 - Generalized Estimates of Probable Maximum Precipitation for United States West of 105 Meridian, 1960.
5. U.S. Weather Bureau, Hydrometeorological Report No. 43 - Probable Maximum Precipitation Northwest United States.
6. Soil Conservation Service, SCS National Engineering Handbook Section 4, Hydrology, 1972.
7. U.S. Bureau of Reclamation, Design of Small Dams, Second Ed. 1974
8. U.S. Soil Conservation Service, Hydrology of Beaver Creek, Havre, MT. In house report, Bozeman Office, 1967.

We appreciate your assistance and cooperation in this study.

Sincerely,



Acting Assistant Area Director, Resources

